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ABSTRACT

This paper describes a program for increasing problem solving and critical thinking skills in mathematics. The targeted population consisted of one kindergarten, one first- and one second-grade classroom in an elementary school located in an older established community 12 miles west of Chicago. The problem was documented through student performance on textbook generated tests, teacher-made tests, California Achievement Tests, teacher observations, and anecdotal comments of other teachers and parents. Analysis of probable cause data revealed that there was little emphasis on problem solving and critical thinking and too much emphasis on rote learning and drill. In addition, teachers felt that they relied too heavily on their own explanations and did not allow their students to actively generate independent solutions. Finally, it was seen that there was a lack of challenging subject matter utilizing higher order thinking skills. A review of solution strategies suggested by authorities in the field and analysis of the problem setting resulted in the selection of mathematics and children's literature with related activities as the intervention to motivate higher order thinking skills. (Contains 26 references and 4 figures of data; appendixes contain pretests, survey instruments, a 16-item annotated bibliography, ranking and graphing sheets, performance assessment forms, and activity sheets.) (Author/RS)

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USING CHILDREN'S LITERATURE TO DEVELOP AND ADVANCE PROBLEM SOLVING AND CRITICAL THINKING IN MATHEMATICS

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An Action Research Project Submitted to the Graduate Faculty of the School of Education in Partial Fulfillment of the Requirements for the Degree of Master of Arts in Teaching and Leadership

Saint Xavier University & IRI/Skylight
Field-Based Master's Program
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Abstract

This report described a program for increasing problem solving and critical thinking skills in mathematics. The targeted population consisted of one kindergarten, one first and one second grade classroom in an elementary school. This school is located in an older established community 12 miles west of a large Midwestern metropolitan city. The problem was documented through student performance on textbook generated tests, teacher-made tests, California Achievement Tests, teacher observations and anecdotal comments of other teachers and parents.

Analysis of probable cause data revealed that there was little emphasis on problem solving and critical thinking and too much emphasis on rote learning and drill.In addition teachers felt that they relied too heavily on their own explanations and did not allow their students to actively generate independent solutions. Finally, it was seen that there was a lack of challenging subject matter utilizing higher order thinking skills.

A review of solution strategies suggested by authorities in the field and an analysis of the problem setting resulted in the selection of mathematics and children's literature with related activities as the intervention to motivate higher order thinking skills.

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CHAPTER 1

PROBLEM STATEMENT AND CONTEXT

General Statement of the Problem

The students of the targeted kindergarten, first and second grade classrooms show no marked progression in the areas of problem solving and critical thinking. Students can answer a given equation in isolation but many cannot answer the same problem when encountered in a story situation or in their daily experiences. The existence of this problem is made evident primarily through student performance on teacher-made tests, text-book company generated tests, the California Achievement Tests (CAT), teacher observations and anecdotal comments from other teachers and parents.

School

This study will be conducted in a prekindergarten through eighth grade school located west of a large Midwestern metropolitan city with an enrollment of 644 students. Of this population 6.2% come from low income households. The ethnic makeup of the school population is 88.7% Caucasian, 9.5% Hispanic, 1.7% Asian, Pacific Islander and 0.2% African American; 8.2% are eligible and serviced in bi-lingual education. This school has an average daily attendance pattern of 95.2% and a 13.1% student mobility rate (Illinois State School Report Card, 1996).

A staff of 40 teachers is employed with a gender breakdown of 92.4% female, 7.6% male and an ethnic breakdown of 97.5% Caucasian and 2.5% Hispanic. The average years of teaching experience are 10.4 years with 58.3% holding a Bachelor of Arts degree and 41.7% holding a Master's degree or above. The average teacher

salary in this district is $31,522.00. The teacher to student ratio is 1 to 18.5 (Illinois State School Report Card, 1996).

District

This is a one school district headed by three administrators with an average salary of $57,167.00. Operating expenditure per student is $4,885.00. Average class size is 20.9 students with 98.1% of the parents meeting with their child's teacher at least once per year. The following services/classes are offered: social work, speech, Title I mathematics/reading, Transitional Program of Instruction (TPI) and enrichment programs.The Regular Education Initiative (REI) has increased the number of children identified with special needs in the regular classroom. To help meet the needs of these children self-contained, resource and team teaching in the regular classroom exist in this school. Along with the traditional curriculum additional subjects include: art, music, computer and organized physical education classes. Student scores on the Illinois Goal Assessment Program (IGAP) tests are above the state average in each of the 13 areas tested. In 11 of the 13 areas 85% of the students meet or exceed the state goals. In order to maintain and improve educational standards the staff is involved in the School Improvement Plan (SIP) for the state of Illinois (Illinois State School Report Card, 1996).

Community

This older established community consists of 9,953 people. The socioeconomic makeup of the community is basically middle-class with an average per capita income of $37,528.00 ranking it 169th out of 262 in a six county area. The education level of the population is as follows: 64.7% have completed high school, 27.8%

have a college degree and 5.5% have not attained a high school diploma. The school's Parent Teacher Association has a membership of 499 members with 100% staff membership. In the spring of 1995 the district was successful in passing a referendum which showed support for the school and allowed the current programs to remain in place. It will also provide for future growth into the twenty-first century.

The area of the community is 2.5 square miles, mainly residential, with a low industrial base. The average purchase cost of a home is $115,000.00 with property taxes of $1,000.00. The racial makeup of the community is 97.5% Caucasian, 4.5% Hispanic, 0.1% African American and 2.5% Other. The median age of the residents is 38.8 years (Commmunity Directory, 1995). Public transportation makes this community easily accessible.

National Context of the Problem

Evidence that there is a national concern in this area is demonstrated by three of the goals cited in the National Council for Teachers of Mathematics (NCTM) "Curriculum and Evaluation Standards for School Mathematics" (1989,p.6). They are "learning to communicate mathematically, learning to reason mathematically and becoming a mathematical problem solver". The NCTM "urges that students no longer merely crunch numbers together in silent practice, but do more writing, reading, and discussing of mathematical ideas with each other".

To achieve these goals classroom teachers need to rethink and reshape their teaching practices. Marilyn Burns, a former classroom teacher, has been at the forefront of the crusade to improve mathematics instruction. She believes that "mathematics

instruction is less about teaching basic computation and more about helping students become flexible thinkers who are able to apply mathematical ideas and skills to a range of problem solving situations" (Whitin, 1993, p.28).

According to Whitin (1992), there is much concern nationally about the mathematical competence of our youth. Students' attitudes towards their competency appear to rapidly decline as they pass fourth grade. We have raised students who are partially competent at pushing symbols but unsuccessful at solving problems and "leave school with a bad taste for mathematics" (Whitin & Wilde, 1992, p.24).

In young children "attempts to elicit explanations about their mathematical thinking often meet with simplistic statements that grossly understate the complexity of the ideas involved" (Schwartz & Brown, 1995, p.350).

Today there is a national call for reform in mathematics education. As stated in a recent issue of "Newsweek" (December,1996), teachers agree that American children should be exposed to more sophisticated mathematics earlier. Pascal Forgione Jr., head of the National Center for Education Statistics, stated, "We expect less of our students and they meet our expectations" (Wingert, p.96). As early as the end of first grade, students in three countries -- Taiwan, China, and Japan -- test higher than American students in most subjects, but particularly in math skills and problem-solving" (Gordon, 1987, p.4). According to The Mathematics Sciences Education Board (1990) the basis for this reform is the widespread belief that the United States must do the following:

> Restructure the mathematics curriculum - both what is taught and the way it is taught - if our children are to develop the mathematical knowledge (and the confidence to use that knowledge) then they will need to be personally and professionally competent in the twenty-first century(p.1).

Traditional mathematics instruction, relying heavily on workbooks, textbooks and teacher explanations, still dominates schools in the 1990's. Continuing this traditional approach offers little hope that children entering kindergarten in 1991 will graduate from the American educational system with the mathematical understandings that will allow them to participate fully as workers and citizens in a contemporary society (Carl, 1988).

Cook (1996) states that The Association for the Supervision of Curriculum Development (1990) reported that in the area of mathematics, while 100% of seventeen-year-old high school students know some basic addition and subtraction facts and are capable of adding and subtracting two-digit numbers, only 5% can solve multi-step math problems. Cody cites A.E. LaPointe, J.M. Askew, and N.S.Mead (1992, p.295), in saying there has been growing evidence that shows "students aren't learning challenging subject matter because they aren't being taught challenging subject matter". Moreover, there has also been "valid criticism that the curriculum had been watered down and higher-order-thinking skills de-emphasized" Cody, 1995, p.295). Lappan and Briars (1995) claim, in order to develop more productive notions about mathematics the following should happen:

> Students must have opportunities to actually be involved in doing mathematical situations, to look for patterns, to make conjectures, to look for evidence to support their conjectures, and to make logical arguments for their conjectures. The situations in which these activities are embedded become part of what is learned and how that learning is remembered and recalled.(p. 134)

Chapter 2

PROBLEM EVIDENCE AND PROBABLE CAUSE

Problem Evidence

Students of the targeted kindergarten, first and second grade classes have exhibited and continue to exhibit difficulty in the areas of problem solving and critical thinking in mathematics. In order to document the extent of the problem, students were given a pretest early in September (Appendix A). The test consisted of items that measured the students capabilities in problem solving and thinking critically. For all grades tested nine of the ten test items were identical. The tenth was made appropriate for each grade level.

Another form of documentation was a survey that was given to teachers of grades kindergarten through fourth and Title I Math (Appendix B). The teachers were asked to use a Likert Scale to reflect and assess the success rate of their students in these areas. This information provided a baseline of students' abilities in the targeted areas. The figures on the following pages show how students performed on the pretest. Each figure is followed by an interpretation and analysis of this information.

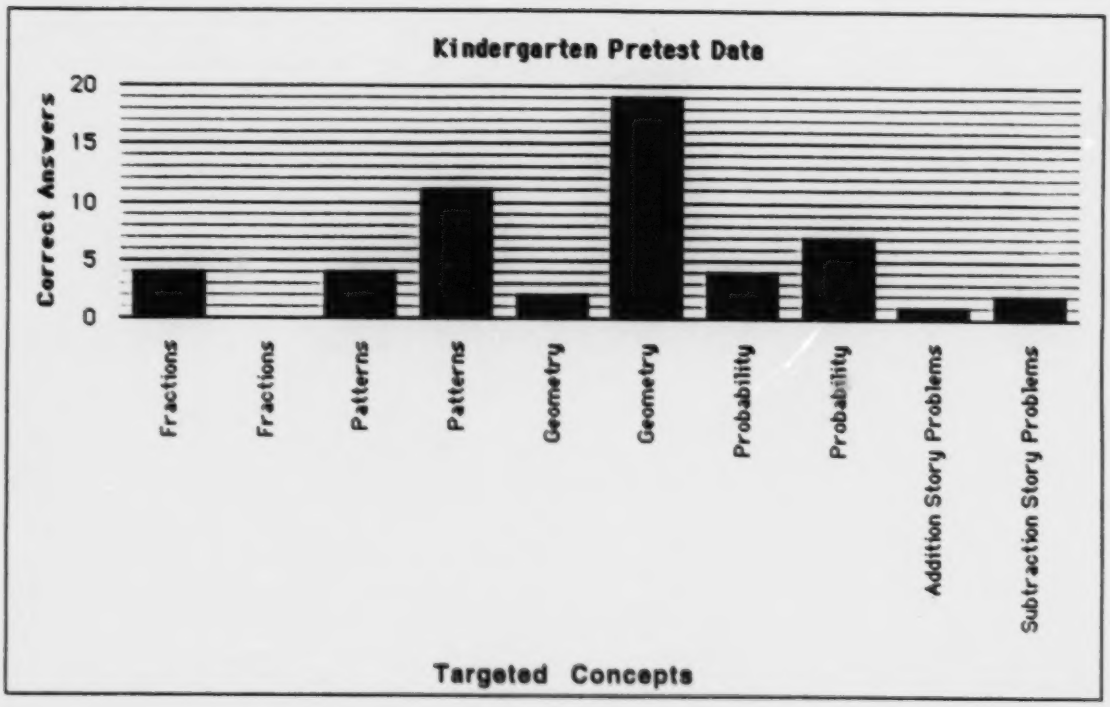

Figure 1. Kindergarten Pretest Data.

Figure 1 indicates the number of correct answers given on the pretest. Using a combined total per concept it can be noted that the kindergarten students scored best on geometry and had the most difficulty with story problems.

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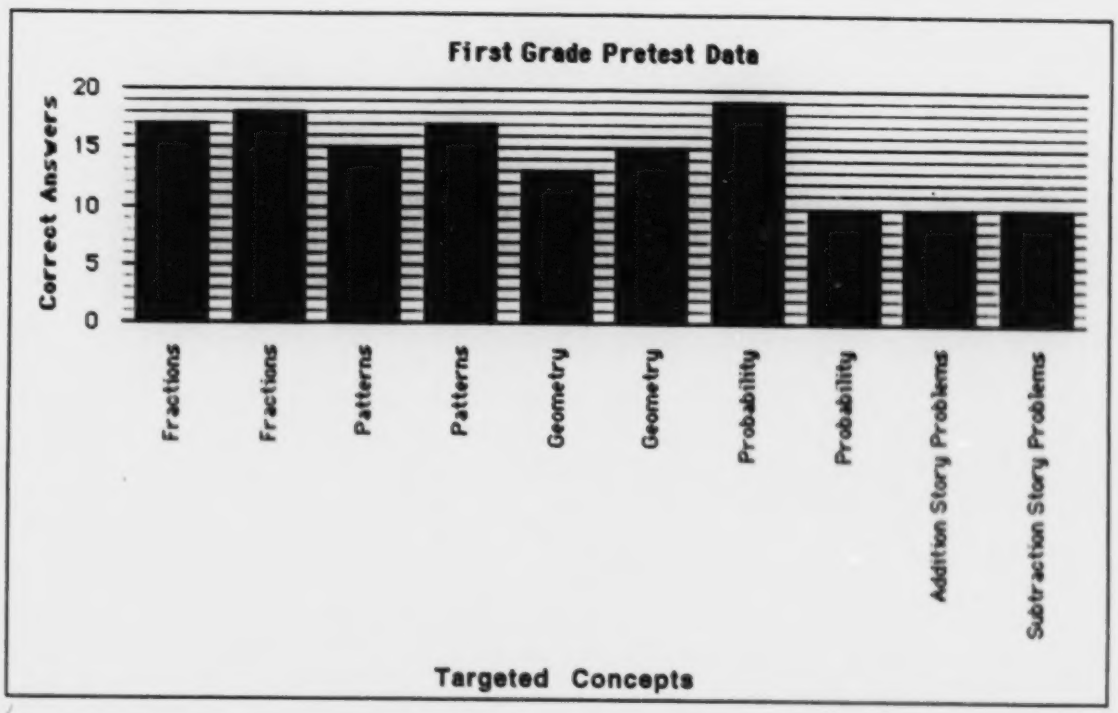

Figure 2. First Grade Pretest Data.

Figure 2 indicates the number of correct answers given on the pretest. Using a combined total per concept it can be noted that the first grade students scored best on patterns and had the most difficulty with fractions.

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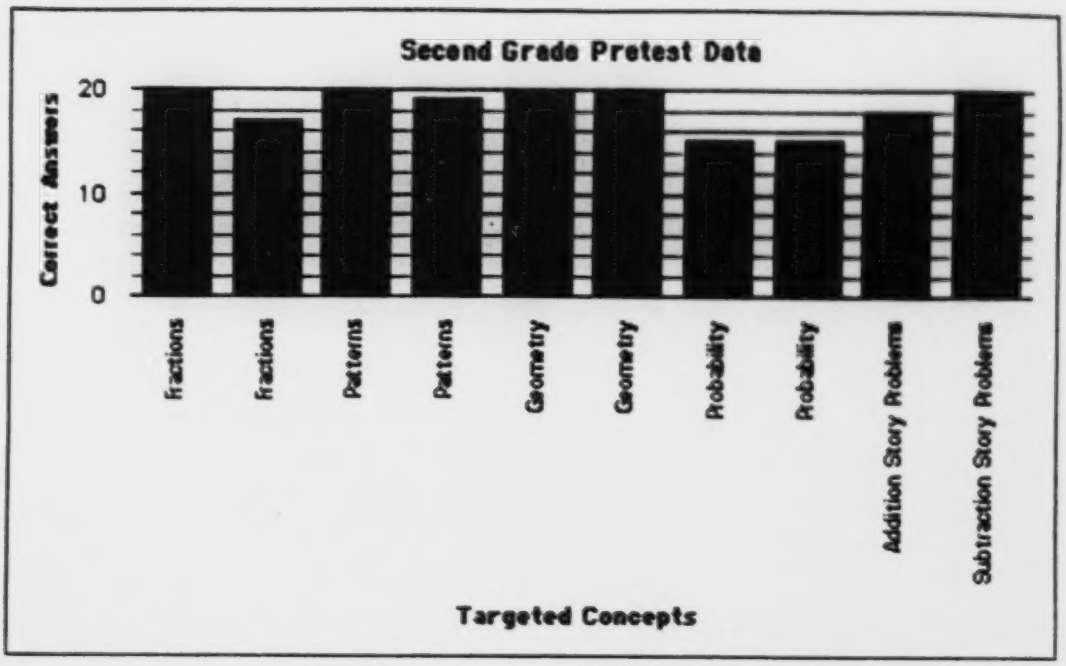

Figure 3. Second Grade Pretest Data.

Figure 3 indicates the number of correct answers given on the pretest. Using a combined total per concept it can be noted that the second grade students scored best on the combined geometry questions and had the most difficulty with probability.

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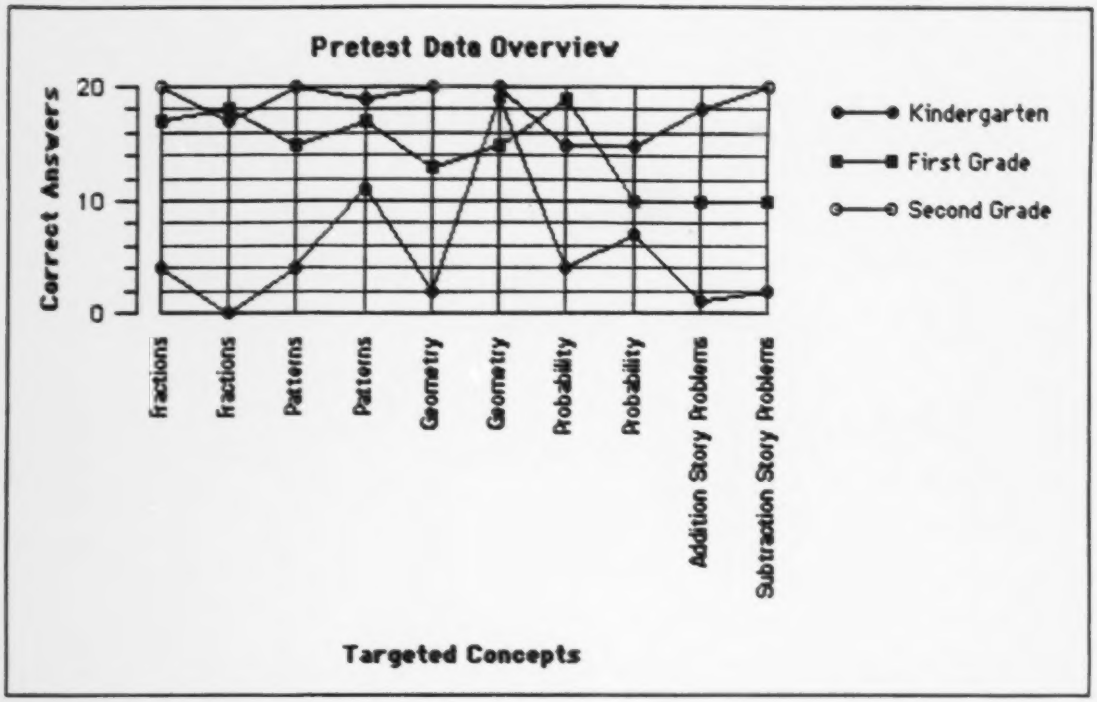

Figure 4. Targeted Grade Levels Pretest Data.

Figure 4 gives an overview of the number of correct answers given on the pretest by the targeted kindergarten, first and second grade classes.

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Factors that need to be taken into consideration when observing the variation in scores are random guessing by some of the students, possible unfamiliarity with the terminology used in the test, and selection maturation interaction (increased school experience) which might inflate the scores in the second grade.

The significant difference in scores is basically due to the experiential level of the students tested. As stated in the latest findings by the NCTM (1989, p.244), student ability to reason, solve problems and use mathematics to communicate their ideas will develop only if they actively and frequently engage in these processes.

In order to evaluate an overall baseline for students' ability levels the results of the baseline test were used to determine the mean and median for each grade level. The mean and median scores for the targeted classes are as follows:

	Mean	Median
Kindergarten	33.5%	30.0%
First Grade	67.0%	65.0%
Second Grade	93.0%	100%

The Likert Scale survey was given to kindergarten through fourth grade teachers asking their opinions of their students' capabilities at problem solving and critical thinking in mathematics. A compilation of these surveys indicated that teachers felt few or some of their students were successful at problem solving and thinking critically (i.e., patterning, alternative solutions and classifying). These same teachers attributed this lack of success to:

- Too much emphasis placed on drill and computation in texts

- Reading level of material above students' abilities
- Critical thinking presented mainly as enrichment for advanced students
- Students not taught problem solving strategies
- Mathematics thought of as being synonymous with computation
- Students were not asked to apply or transfer skills
- Younger students were not perceived to be developmentally ready to use higher order thinking skills
- Poor listening skills
- Cooperative groups not utilized sufficiently to help foster problem solving
- Students were spoon-fed information and given little opportunity for independent thought

Parents were also surveyed using a Likert Scale (Appendix C). The most pertinent information garnered from this survey dealt with parents'perceptions that their children were more apt to seek help rather than attempt to find a solution on their own.

Probable Causes

Clara M. Jennings (1992) believes mathematics instruction in 1991 was dominated by paper-and-pencil drill, memorization of facts and algorithms, teacher explanations, chalkboard presentations, and a heavy reliance on workbooks and textbooks rather than on reasoning and problem solving .

From 1991 to 1996 the Houghton Mifflin mathematics series (1989), used at the targeted school, emphasized this repetition, drill, and memorization over higher order thinking skills such as evaluating, predicting, reasoning and problem solving. The constructivist belief is that it is far more important for

students to understand mathematical concepts and ideas than to simply acquire skills. Students will be more receptive to learning the skills if the need becomes apparent and purposeful to their lives.

When reviewing current literature several causes were presented which might explain students' difficulties with problem solving and critical thinking. The idea that students developmentally progress from low-level thinking to high-level thinking seems to have no basis in reality. Students of various backgrounds seem quite able to grasp sophisticated concepts when given meaningful opportunities. Conceptual understanding and knowing what mathematical ideas apply to a situation have become far more important than mastery of specific skills and facts. Today we have redefined mastery to mean the deep understanding that comes from personal investigation of problems and thinking about important mathematical ideas rather than the detailed accuracy that comes from repeated drill and practice on low-level skills. The traditional approach of teaching to merely acquire computational skills has produced students weak in higher order thinking skills. This same thought is supported by John Dewey (1910) as cited by Kilpatrick and Stanic (1995). There is...

> danger in those studies where the main emphasis is upon the acquisition of skill. Practical skill, modes of effective technique, can be intelligently, non-mechanically *used* only when intelligence has played a part in their *acquisition* (p.10).

Whitin and Wilde (1992) have also stated:

> Math folks express concern that we tend to teach the parts - arithmetic facts and skills through meaningless drill so that learners lose the context and do not develop a sense of mathematical functions. They are concerned that youngsters are not learning to think mathematically or to see math in all of their life experience (p.IX).

The NCTM (1989) supports these probable causes by stating, "Children lose their belief that learning mathematics is a sense-making experience. They become passive receivers of rules and procedures rather than active participants in creating knowledge" (p.15).

Part of the responsibility lies with traditional teaching methods. Lappan and Briars (1995) express their feelings as follows:

> Teaching to develop problem solving, reasoning and communication skills requires a very different style of instruction from teaching technical skills such as computational algorithms and procedures. Reform is about teaching for understanding and teaching to promote students' confidence in themselves as mathematics learners and doers rather than teaching students to be proficient at executing standard procedures (p.132).

This problem is exacerbated by teachers who do not spend enough time teaching about the philosophical questions (Romberg,1988).

1. What is mathematics?
2. Which mathematics should be taught?
3. How do people learn mathematics?
4. How can mathematics be taught effectively? (p.1-2)

In the past students were not encouraged to look for alternative solutions. Steen and Formon (1995) corroborate:

> Mathematics in context, is typically very concrete but not necessarily very straight forward. Problems arising from real solutions can be solved in a variety of ways and do not necessarily have unique "correct" answers. Several strategies may be "good enough" (p. 221).

As previously stated there are many probable causes as to why students are unable to problem solve and think critically. These may include:

1. Lack of higher order thinking skills
2. Excessive emphasis on computation
3. Meaningless drill
4. Students are passive learners
5. Antiquated and traditional teaching methods
6. Students are not encouraged to come up with alternative solutions.

Campbell and Johnson (1995) state:

> While the intent of mathematics instruction

was to stimulate recall and mathematical skills and rules, the goal today has advanced to mathematical understanding. (p.23-24)

Chapter 3

THE SOLUTION STRATEGY

Review of the Literature

The research continually stated the need for classroom teachers to broaden the mathematics curriculum so as to de-emphasize rote learning and emphasize "skills not as an end in themselves but as means to other ends" (Kilpatrick and Stanic, 1995). Mathematics needs to be made more concrete by engaging students in activities that involve many learning styles. Other means must be found in order for students to write, draw, build, walk and talk mathematics (Moss,1997).

Teachers' primary goal should be that all students gain "mathematical power". The NCTM (1989) defines mathematical power as:

> an individual's abilities to explore, conjecture, and reason logically, as well as the ability to use a variety of mathematical methods to solve non routine problems. Problem solving should be the central focus of the mathematics curriculum. Problem solving is not a distinct topic but a process that should permeate the entire program and provide the context in which concepts and skills can be learned. (p.26)

According to Cuevas (1995), being mathematically literate in the 1990's means:

> Having the power to use mathematics for your own purposes as well as those that the institutions

> of our society require of us. As students develop literacy, they must be encouraged to explore and analyze critically the mathematical content they are learning. (p. 69)

Elementary school mathematics should develop students' abilities to think, reason, solve problems, communicate with mathematics, access children's natural curiosities and connect mathematics to their world. This then implies that students, teachers, administrators, parents and community members must implement a plan for improving mathematics education.

In order to function in today's technological society children can no longer be taught only to memorize arithmetic facts; they must develop a mathematical orientation toward understanding, analyzing, and solving problems (Jarvis & Blank, 1988).

The NCTM (1989) believes teachers can move toward the new vision of the math classroom by:

> transforming classrooms into learning communities of active and collaborative mathematical inquiry; teachers will need to access and be able to use instructional materials for thought-provoking activities and projects, and resources in the community for authentic learning experiences. To implement reforms that engage all students in meaningful mathematics learning, teachers will need to learn a new role as a facilitator and coach in the classroom, and expand their knowledge base in mathematics, develop new curricular and instructional strategies, and change their expectations for students. (p.5)

In the past, teachers' goals were to teach students *a single* method to arrive at a correct answer. The NCTM states the primary

method to arrive at a correct answer. The NCTM states the primary goal for the study of mathematics is to give children experiences that promote the ability to solve problems and that build mathematics from situations generated within the context of everyday experiences. Students should be expected to make conjectures and conclusions and to discuss their reasoning, both orally and written, using pictures, graphs, charts and manipulatives. Moreover, students learn to value mathematics when they make connections between topics in mathematics, between the concrete and the abstract, between concepts and skills, and between mathematics and other areas in the curriculum.

The literature reviewed often recommended children's literature in mathematics to be a valuable tool. It is a rich resource for developing mathematical power. Through sharing books children will gain confidence in their mathematical problem solving abilities. Children's literature offers a great starting point for mathematical thinking based on real problems of interest both to children and to teachers by adding depth to concepts and helping to develop relationships among and between mathematics topics. Children's books help make interdisciplinary connections that stimulate student interest and provide reminders of the usefulness of mathematics. Stories also encourage productive thinking among children and provide teachers with insight into their thinking processes. Young students are often not perceived to be developmentally ready to use higher order thinking skills; however, designing developmentally appropriate activities through the use of literature helps foster discussion among children, a necessary part of understanding and applying mathematics to new problem-solving situations (Jennings, Richey, and Dixon-Krauss,

1992). Bruner (1960) believed that any subject could be taught effectively in some intellectually honest form to any child at any age of development. Children's literature provides such a form.

Children's literature helps students to see that mathematics is useful and allows them to become receptive to more advanced learning. The NCTM (1989) recommends making reading and children's literature an integral part of mathematics. The opportunities to explore mathematics through such a format are limitless. Children's literature is rich with opportunities for young people to think and reason (Spann, 1992).

Project Outcomes and Solution Components

After researching the problems of students' inability to transfer abstract mathematical concepts into their everyday lives, problem solve and think critically, many causes were explored. Using the information gathered during research, it was determined that using children's literature would be our intervention to help increase students' ability in these areas.

As a result of incorporating literature with mathematics, during a seventeen week period between the months of October and February, the targeted kindergarten, first and second grade classrooms will show marked progression (increased skills) in the areas of mathematical problem solving and critical thinking as measured by pretests, performance based tests, post tests and student portfolios.

In order to accomplish these objectives the following must be done:

1. Teachers will select five mathematical concepts to be targeted.

mathematical concepts (the same books will be used in each of the three classrooms).

3. Lesson plans will include students working as a whole class, in cooperative groups, in partners and individually.

The following are components to the solution:

1. Parent(s)/Guardian(s) will be surveyed regarding their opinion of their child's strengths and knowledge and application of mathematical problem solving and critical thinking skills.
2. In September, students will be given a pretest that will determine their present level of knowledge and application in mathematical problem solving and critical thinking skills.
3. Teachers will read selected literature weekly to their class.
4. As a large group, cooperative group, in partners or individually, students will do an activity related to the chosen literature books. Students will use various materials and manipulatives to carry out the activity.
5. At the conclusion of each lesson taught a performance based assessment will be given.
6. Pieces placed in the portfolio will be tagged by the student (Appendix D).
7. At the conclusion of the seventeen weeks, students will be given a post test identical to the pretest, that will show if there has been marked progression (increased skills) in the mathematical areas of problem solving and critical thinking.

problem solving and critical thinking.

8. Additional assessment will be in the form of teacher observation and portfolio pieces.

Action Plan for the Intervention

The annotated bibliography used to affect this intervention can be found in Appendix E.

Week 1

Administer pretest (Appendix A) to all students in the targeted kindergarten, first and second grades.

Week 2

Mathematical Concepts: Probability

Literature Book: Gregory the Terrible Eater, by Mitchell Sharmat

Activity:

1. Read and discuss book as a class.
2. Using an enlarged copy of an "Agree/Disagree" chart (Appendix F) and individual copies, each child will predict which teacher selected objects will sink or float. A variety of objects mentioned in the book will be tested such as a rubber heel, a banana, a can of soup and a carrot.
3. The whole class will watch the teacher place each object into a tub of water to test for flotation.
4. Record results on a large chart.
5. Discuss possible reasons for results.

Week 3

Mathematical Concept: Probability

Literature Book: The M&M Counting Book, by Barbara Barbieri McGrath

Activity:

1. Read and discuss book as a class.
2. Based on prior knowledge, partners will predict the colors in order of occurrence from most to least using a ranking sheet (Appendix G).
3. Children will individually sort the candies from a snack size M&M bag by color from most to least and record results on a graphing sheet (Appendix H).
4. As a class, comparisons will be made of the predictions and the actual findings with a discussion of probable reasons for the results.
5. Using a second bag of M&M's, a new prediction will be made by each child using this new knowledge of probability. At the kindergarten level a ranking sheet will be used a second time. Each student will be asked to justify his/her predictions in order to assess understanding of this concept.
6. Results from the second bag will be graphed.
7. A display will be made of predictions and results.

Week 4

Performance Assessment: Probability

1. Each child will be given a brown bag, unbeknownst to them it will contain seven unifix cubes, four red, two blue and one orange.
2. Students will empty the bag to quickly view the contents and then replace them.
3. Students will predict which color has the highest probability of being pulled out in ten attempts and explain reasoning for prediction. A Likert Scale

(Appendix I) will be used to rate their explanation.

4. Students will shake the bag to distribute the contents and pull out a cube without looking, keeping a tally of each color removed.
5. Class discussion on results.

Week 5

Mathematical Concept: Patterns

Literature Book: Sam Johnson and the Blue Ribbon Quilt by Lisa Campell Ernst

Activity:

1. Read and discuss book as a class.
2. Each pair of students will be given a ten inch square piece of construction paper. Using contrasting colors students will be given nine two inch squares and nine triangles, which are half of the squares, to construct and identify a pattern of their own.
3. Finished squares will be combined to form a larger "quilt" noting patterns that are seen.
4. A large "quilt" using all three classes' finished products will be constructed and displayed.

Week 6

Mathematical Concepts: Patterns

Literature Book: The Legend of the Indian Paintbrush by Tomie dePaola

Activities:

1. Read and discuss the book as a class.
2. Students will be asked to develop a pattern using two or three colors. The pattern will be recorded on a

strip of graph paper as well as verbally explained to the teacher.

3. Students will copy their pattern onto a half piece of white coffee filter using water based markers. These filters will be folded into triangles and dipped into water to distribute the color.
4. Once dried, the filters will be posted onto a blue background with the original graph pattern attached and then displayed.

Week 7

Performance Assessment: Patterns

1. Students will be given the opportunity to choose from four colors of mostaciolli to generate a pattern which will be used to make a necklace.
2. Prior to stringing the pasta on lengths of yarn, the pattern will be illustrated on graph paper.
3. The completed necklace and pattern will be posted and displayed.
4. The completed product, showing the students' ability to create a pattern, will be evaluated through the use of a rubric (Appendix J).

Week 8

Mathematical Concept: Geometry

Literature Books: If You Look Around You by Fulvio Testa, Shapes by William Wegman, and Alphabet City by Stephen T. Johnson

Activities:

1. Read and discuss books as a class.
2. Students will identify shapes found in the classroom.

3. Students will be given a worksheet with the targeted shapes (Appendix K). They will record examples of each shape as found on walks outdoors and within the school building.
4. Students will share findings.
5. Students will look in their own homes for examples of the shapes discussed and bring these to school for display (Appendix L).

Week 9

Mathematical Concept: Geometry

Literature Book: Round Trip by Ann Jonas

Activity:

1. Read and discuss book as a class.
2. Partnered students will be given a sheet with eight illustrations (Appendix M). Students sitting opposite one another will tell their partners what they see. Students will switch sides and repeat activity.
3. Observations will be discussed and recorded.

Week 10

Mathematical Concept: Geometry

Literature Book: What is Symmetry? by Mindell and Harry Sitomer

Activity:

1. Read and discuss book as a class.
2. Teacher will demonstrate activities, such as making paper dolls and punching holes in folded paper, as stated in the book. Predictions will be made based on results.
3. Students will be free to experiment with similar activities on their own.

4. Each student will be given the letters of his/her name on three inch squares of paper. They will look for line symmetry by folding the paper horizontally and vertically.
5. Using a yes/no chart (Appendix N) students will glue the letters of their name under the correct heading depending upon whether or not these letters show symmetry.
6. Teachers will discuss and assess charts with individual students.

Week 11

Performance Assessment: Geometry

Literature Book: Changes Changes by Pat Hutchins

Activity:

1. View picture book and discuss.
2. Each child will be asked to use the five targeted shapes plus any number of additional pieces to create a picture.
3. Each child will present these finished pictures to the class and identify the shapes.
4. Students will be evaluated on a Likert Scale (Appendix O) based on their knowledge of the shapes, creativity and uniqueness of their picture.

Week 12

Mathematical Concept: Fractions

Literature Book: Eating Fractions by Bruce McMillan

Activity:

1. Read and discuss book as a class.

2. Discuss the concepts of whole and fractional parts (1/2, 1/3, 1/4).
3. Divide students into groups of four or five. Each group will receive an apple cut into unequal fourths or fifths.
4. Discuss whether or not students received a "fair share" of the apple. Eat the apple.
5. Next, each group will receive a Hershey candy bar to divide equally among members.
6. Discuss the manner in which it was divided and the reasons for that choice. Eat the candy bar.

Week 13

Mathematical Concept: Fractions

Literature Book: Gator Pie by Louise Matthews

Activity:

1. Review the meaning of fractions as equal parts of a whole or "fair shares".
2. Read and discuss book as a class.
3. Teacher will demonstrate how to make new words from fractional parts of others using large paper letters as manipulatives.
4. With a partner, students will be given a worksheet directing them to make new words from fractional parts of others (Appendix P).
5. Discuss results.
6. Identify shaded fractional parts drawn on the chalkboard for practice.

Week 14

Performance Assessment: Fractions

1. Each child will randomly choose a fractional recipe card (Appendix Q) and match it to a corresponding paper pizza base (Appendix R).
2. Toppings will be applied according to the fractional recipe card.
3. Each student will write the fraction of their pizza that is plain cheese.
4. Evaluation will be made by using a yes/no checklist (Appendix S).

Weeks 15

Mathematical Concept: Addition and Subtraction

Literature Books: Rooster Off to See the World by Eric Carle
1 Hunter by Pat Hutchins

Activity:

1. Read Rooster Off to See the World and chart the addition/subtraction problems as the story progresses. Review addition as the joining together of groups and subtraction as the separation of groups.
2. Read 1 Hunter and use the illustrations to predict how many animals were hidden.

Week 16

Performance Assessment: Addition and Subtraction

Literature Books: Five Ugly Monsters by Tedd Arnold
How Many Snails? by Paul Gigante

Activity:

1. Read Five Ugly Monsters and How Many Snails? and note how the illustrations depict the concepts of addition and subtraction.
2. Students will practice illustrating verbal number sentences dictated by the teacher.
3. Student pairs will be given related number sentences to illustrate after deciding on a common theme.
4. Each student will verbally explain his/her illustration.

Methods of Assessment

In order to assess the effects of the interventions, after a four month period, students will again be given the same tests administered in September. The percentages indicating the number of correct answers will be compared. The tests will reflect students' ability to problem solve and think critically. In addition to comparing the pretest and post test scores, teachers will be reviewing student portfolios, performance outcomes, anecdotal records and at the second grade level math journals. The percentages will be looked at to see if there is an increase in the number of correct responses. These methods will help determine if the interventions were successful.

Chapter 4

PROJECT RESULTS

Historical Description of Intervention

The main objective of this project was to increase problem solving and critical thinking skills at the kindergarten, first and second grade levels. The implementation of children's literature with related activities to teach mathematical concepts was selected to effect the desired changes. At the beginning of the year students were given a pretest on the concepts to be covered by the implementation: probability, patterns, geometry, fractions, addition and subtraction.

The concepts were initially presented to the entire class. The related activities were then carried out by individuals, partners or cooperative groups. Parent and teacher surveys along with pretests were administered in September of 1996 to establish a baseline of knowledge and attitudes towards critical thinking, problem solving and mathematics. The intervention was employed during mathematics class two days a week for a seventeen week period. Lesson plans devoted to each concept can be found in Chapter 3.

Each of the targeted concepts was allotted a two week period of instruction followed by a performance assessment activity. Throughout the intervention teacher observations were recorded to assess the students skill development and problems encountered. The second grade teacher also made use of journals to keep track of students grasp of the concepts. As projects were completed students kept their work in decorated shopping bag portfolios which were displayed in the classroom. At the conclusion of the

intervention, students were asked to tag their pieces with various headings described in Appendix D. At the end of the seventeen week period students were given a post test, identical to the pretest, to show if there had been any marked progression (increased skills) in the mathematical areas of problem solving and critical thinking. Upon reflection it was determined that a follow up parent survey would be valuable to further assess the students knowledge and attitudes in the above mentioned areas.

Presentation and Analysis of Results

In order to measure the effects of the mathematics intervention the post tests were examined. The following figures show how students performed on the targeted concepts. Each figure is followed by an analysis of this information.

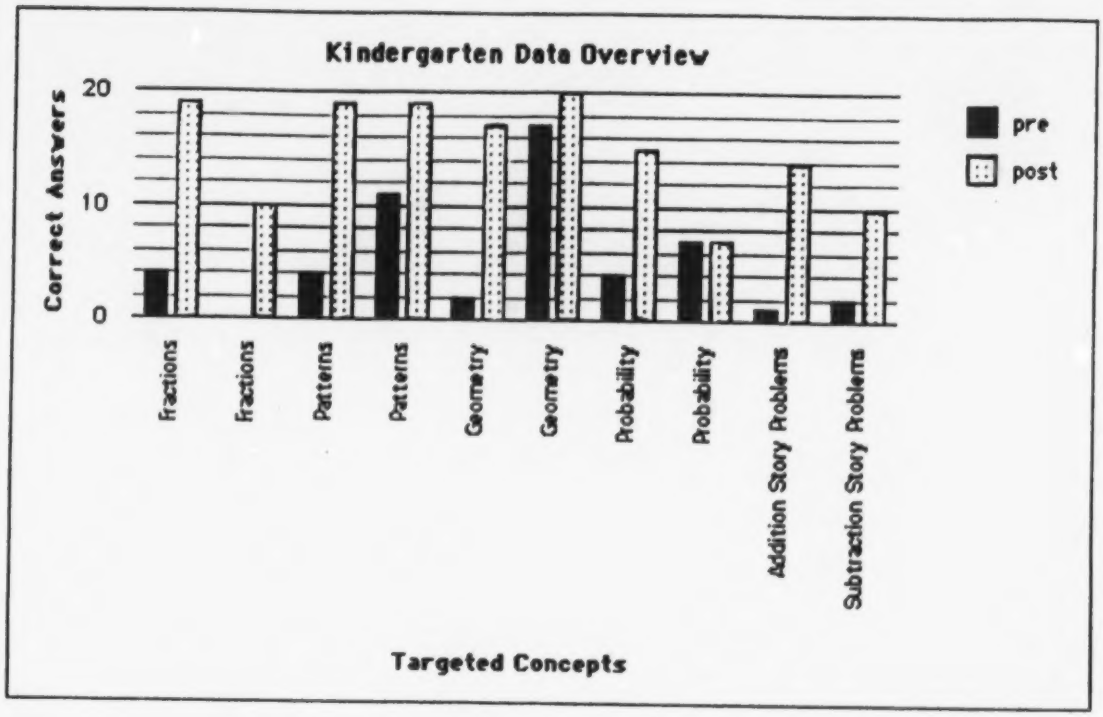

Figure 1. Kindergarten Post Test Data.

Figure 1 indicates the number of correct answers given on the post test. There was an overall marked improvement in all areas. Using a combined total per concept it can be noted that the kindergarten students were most improved in the concept of fractions with an overall percentage of 62.5. The area which continues to cause difficulty is probability with a 27.7% increase.

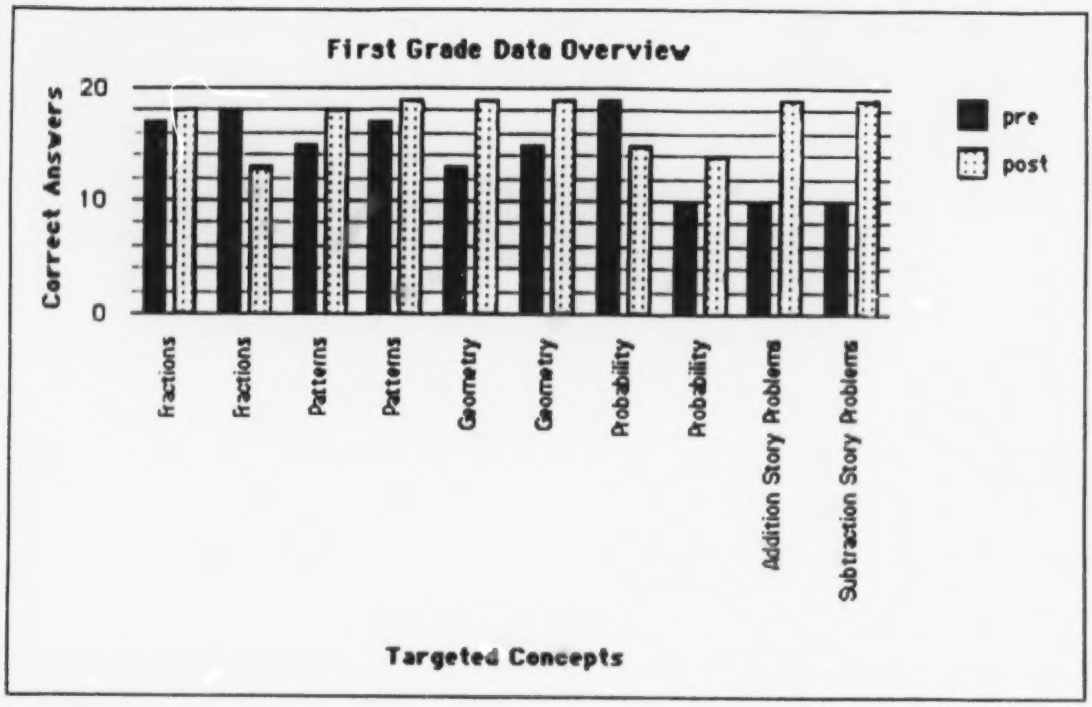

Figure 2. First Grade Post Test Data

This figure indicates the number of correct answers given on the post test. Using a combined total per concept it can be noted that the first grade students scored best on addition and subtraction story problems with an overall percentage increase of 25. The concept of fractions caused the first grade students the most difficult. It should be noted that the intervention began with twenty students, but due to student mobility ended with nineteen. This is reflected in the post test data.

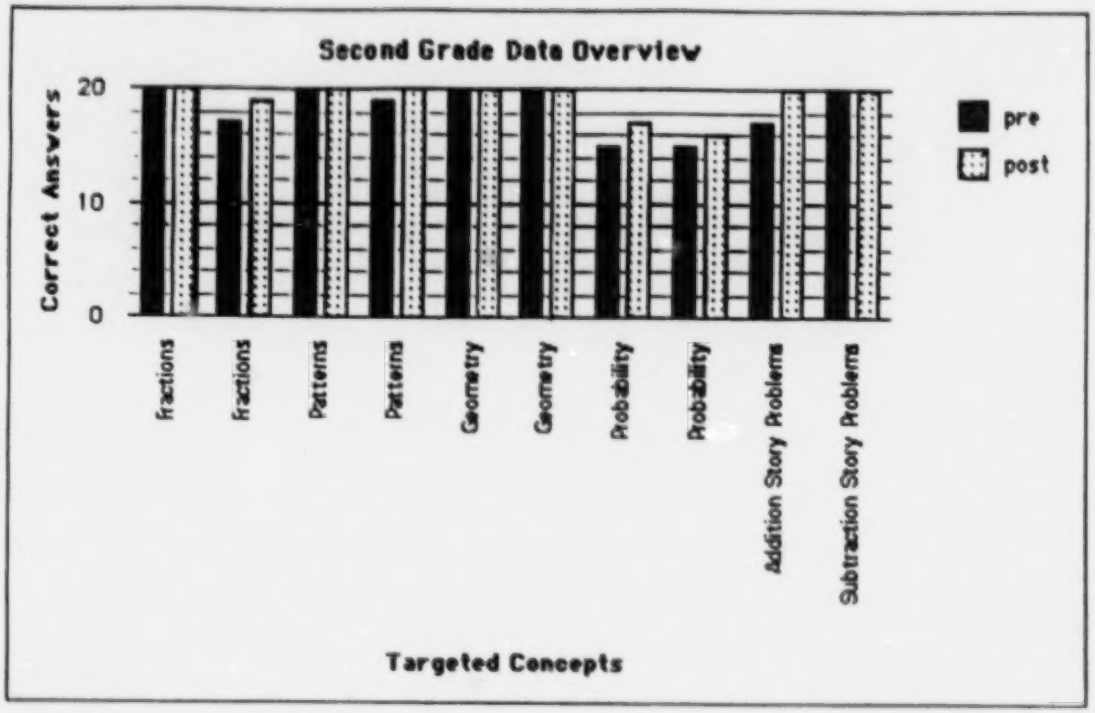

Figure 3. Second Grade Post Test Data.

This figure indicates the number of correct answers given on the post test. It should be noted these scores have been modified due to the fact that once the standardized test was administered the scores were skewed. Upon analyzing the test results the researcher discovered a deviance between some test scores and the knowledge exhibited by the students during the intervention. Items in question were verbally administered and these are the results. Using a combined total per concept it can be noted that the second grade students scored best on probability as well as on story problems involving addition and subtraction.

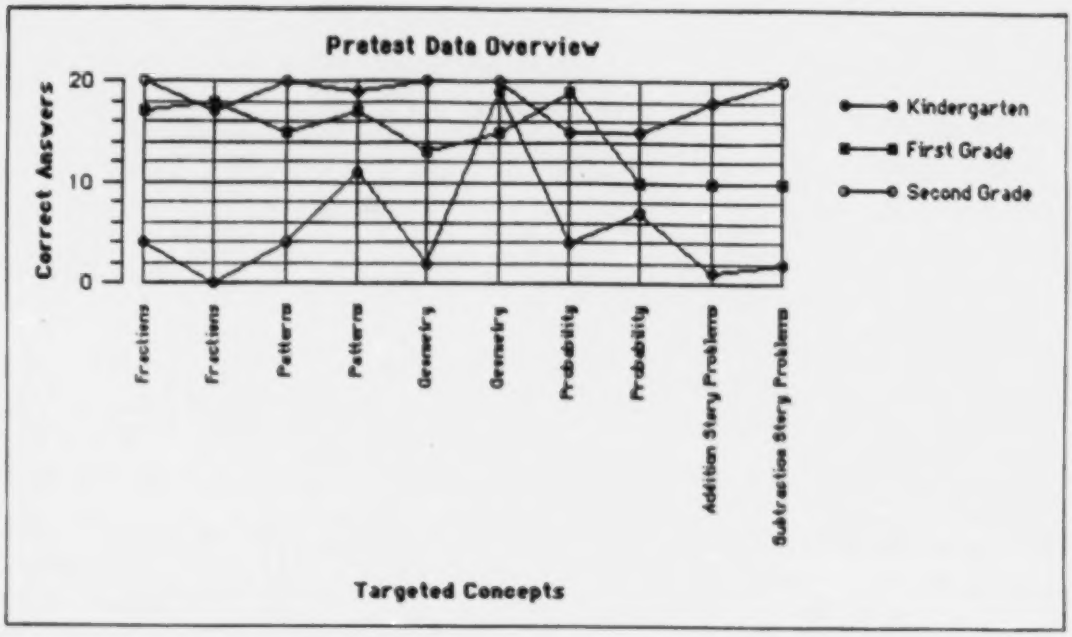

Figure 4. Pretest Data Overview

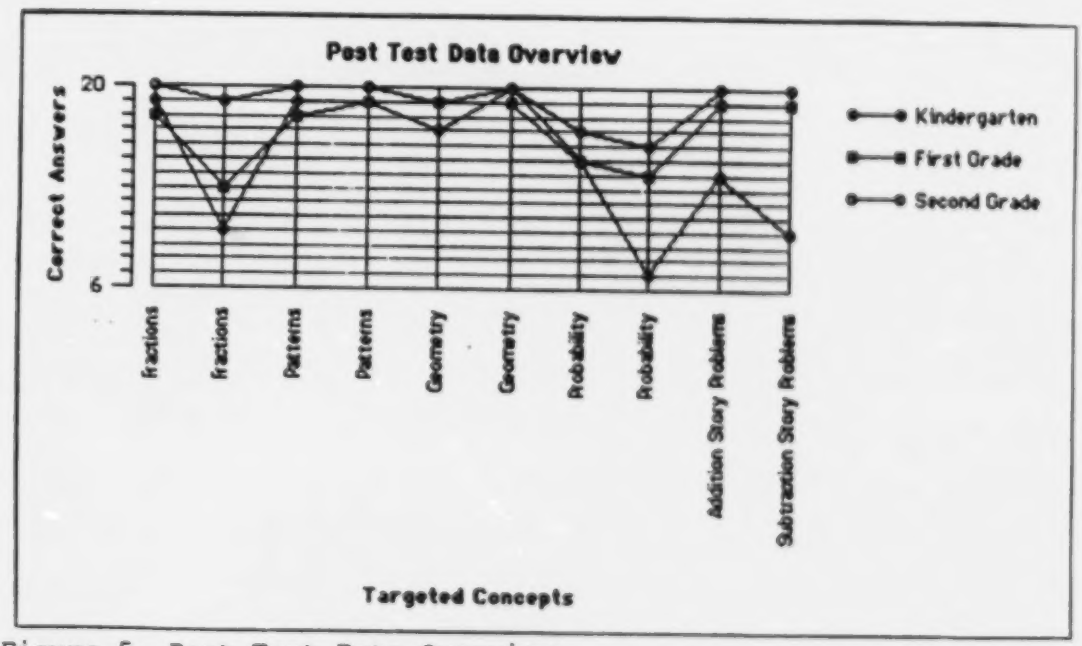

Figure 5. Post Test Data Overview

From Figures 4 and 5 it was found that students showed marked improvement in the areas of patterns, geometry, addition and

subtraction story problems. A slight improvement was evident in the areas of fractions and probability. Compared to the baseline scores kindergarten had a mean score increase from 33.5% to 85%, first grade had a mean score increase from 67% to 91.5%, and finally second grade increased from 93% to 97.5% .Comparing the baseline median scores, kindergarten showed a 40% increase from 30% to 70% , first grade showed a 25% increase from 65% to 90% and the second grade median remained unchanged at 100%.

Through studying anecdotal records the researchers found that everyone understood the concept of fair share or equal parts of a whole. When presented with a shaded figure 74% of students understood that the denominator shows how many parts are in a whole and that the numerator depicts the shaded part of the whole.

Second grade students were asked to apply this concept during the school day. (e.g. "What fraction of this table of students has handed in their work?") They were able to quickly answer correctly thereby showing integration of the concept.

The researchers have also observed that students have become very aware of patterns in their environment from noticing children's clothing to repetitive patterns in stories. This was the first time in seven years the kindergarten researcher observed mastery of this concept by the end of the first semester. This same researcher noticed transfer was evident later in the year when the students were asked to complete the missing half of a picture. Their response was,"This is symmetry".

The activities related to the concept of geometry were thoroughly enjoyed by the students. They were completely immersed in the search for geometrical shapes. At present they continue to

correctly identify the shapes using the vocabulary they were taught.

Although there was an overall improvement, from the pretest to the post test, in the concept of probability the researchers continue to sense uncertainty in this area. When asked in classroom situations to apply what they have learned a few students still cannot support their choices by using the laws of probability. The researchers feel this concept to be abstract and one which confounds many adults. However, many students continue to investigate the probability of colors in a bag of M&M candies. By introducing this concept at a young age it is hoped that students will be open and familiar to future exposures. The first and second grade teachers will have the opportunity to track progress in this area.

Finally, regarding the concepts of addition and subtraction story problems, students at the kindergarten level made a 59.3% increase in these areas. One hundred percent of first and second grade students answered the questions on addition and subtraction correctly. They are now able to use the information given to them and arrive at a correct answer.

As a result of teacher observation, examination of portfolio pieces and results of performance based assessments, the researchers were able to further evaluate progress. It was noticed that more reinforcement will be necessary in the areas of fractions and probability. The researchers were pleased with the observations that students exhibited creativity, enthusiasm, and initiative in their mathematical undertakings. During individual portfolio conferences the researchers were able to gain insight into student thinking as reasons were verbalized. As the students

tagged their portfolio pieces the researchers were able to assess the areas the students felt competent in and those areas which still caused them some frustration. The tagging results paralleled the test results in that the areas the students chose as their strengths and weaknesses were reflected in the test data.

Another tool that helped the second grade teacher further assess learning was the use of mathematical journals. Explaining their reasoning through writing became an additional method to extend mathematics across the curriculum. In the future the kindergarten and first grade teachers would utilize mathematics journals for the same reasons they were used in the second grade. The journals would be mainly illustrative rather than written.

Conclusions and Recommendations

One of the researchers' initial goals was to encourage problem solving and to move away from practice and drill hence, all of the activities were planned around problem solving strategies. By physically involving students in projects where they have had the opportunity to use models, manipulatives and to create a product, the researchers have moved them away from merely crunching numbers. These activities created the need for students to make decisions on how to utilize the skills learned in order to complete their project. They are now cognizant of the fact that there are many ways, not one right way, to arrive at a solution. Children's background experiences influence their choice of methods at arriving at an answer.

Collaborative group and partner work allowed children to discuss reasons for their choices and to discuss mathematical ideas with others. Presentations allowed them to see how others

visualized mathematical ideas and also allowed students to feel competent and confident in their mathematical abilities. The researchers have also discovered that students' problem solving abilities have developed such that they are able to determine answers that require some critical thinking skills, e.g. in the question "About how many books has the teacher read to the class so far this year?" the students were able to arrive at a plausible answer using information available within the classroom. Students have also been able to estimate and predict in practical classroom situations. The researchers have gained confidence that when students are challenged they will rise to meet expectations.

Another positive aspect of the intervention has been the exposure of young primary students to concepts generally saved for older students. The researchers are encouraged that challenging critical thinking skills were successfully presented to all students and not just as enrichment for advanced pupils. A conscious effort to not water down the curriculum was made. In discussing results with the district mathematics coordinator, it was related that although this is a difficult concept, it is important to lay an early foundation in this area as it continues to be a challenging concept to grasp throughout the upper grades.

The children's literature used allowed mathematics to become part of the students' life experience. The illustrations in the books helped them visualize the problems. Children expressed regret that the intervention had been completed. It has become obvious that they enjoy mathematics and see it as a part of their lives. Parents have commented positively on the enthusiasm their children have for mathematics this year and they have noticed the use of terminology and vocabulary that has been taught and

children have for mathematics this year and they have noticed the use of terminology and vocabulary that has been taught and encouraged at school.

The researchers will continue to use this approach. An attempt will be made to look at the literature read in the classrooms with an eye for how it may be adapted to critical thinking and problem solving skills. Although both the teachers and students enjoyed and benefited from this approach to teaching mathematics, the researchers are not entirely free to use this singular method in the curriculum due to the constraints placed by district requirements.

The researchers hope that school districts that allow action research to go forward would be willing to incorporate successful results into existing curriculum. The research should be valued as a cutting edge educational tool and not merely an advanced degree requirement.

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APPENDICES

Appendix A
Kindergarten Pretest

1. Which picture shows that every child would get the same amount?

2. Which shows one third?

3. What shape comes next in the pattern?

Which set of numbers comes next?

4, 5, 6, _, _, _

3, 9, 20
5, 12, 13
17, 18, 19
7, 8, 9

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Appendix A
First Grade Pretest

1. Which picture shows that every child would get the same amount?

2. Which shows one third?

3. What shape comes next in the pattern?

Which set of numbers comes next?

10,20,30,_,_,_

3,9,20
40,50,60
70,71,80
20,25,30

Appendix A
Second Grade Pretest

1. **Which picture shows that every child would get the same amount?**

2. **Which shows one third?**

3. **What shape comes next in the pattern?**

4. **Which set of numbers comes next?**

2, 4, 6, 8, _, _, _

3, 9, 20

10, 12, 14

10, 15, 16

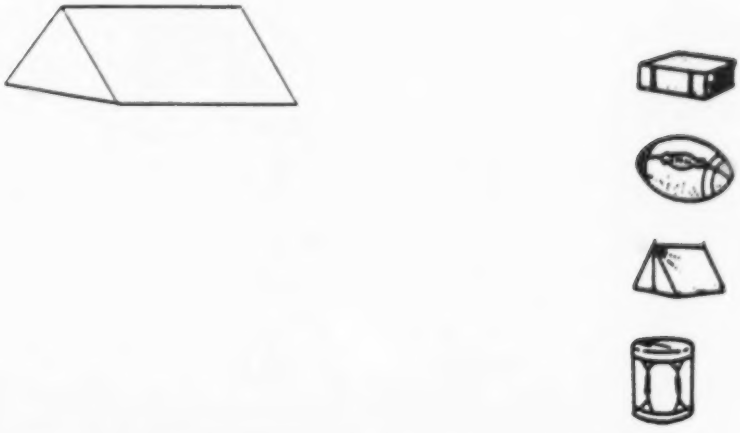
18, 20, 22

Appendix A
Pretest Page 2 Kindergarten/First/Second

Pretest/Post test -2

5. Which picture shows two parts that match?

6. Which one is the same shape?



7.

If these squares were in a .

Which one do you think you would pull out most often?

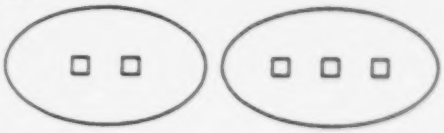
Appendix A
Pretest Page 3 Kindergarten/First/Second

Pretest/Post test-3

8. Yellow Red Blue

If you were walking on this line and had to stop when the music stopped, you would have a better of landing on which space?

9. Look at the picture. Which addition sentence tells how many in all?



4+5=9
2+3=5
5+3=8
2+2=4

10. There are 8 apples in the bowl.
3 apples are eaten.
How many apples are left in the bowl?
Choose the number sentence that tells the story.

8+3=11
3+5=8
8-3=5
11-8=3

Appendix B
Teacher Survey

Teacher Survey

Please place an "X" on the line nearest the response of your choice.

In your experience teaching mathematics, how many of your students have been capable at problem solving(story problems)?

None of the children	Few of the children	Some of the children	Most of the children

In your experience teaching mathematics, how many of your students have been capable at critical thinking (ie.patterning, alternative solutions, classifying)?

None of the children	Few of the children	Some of the children	Most of the children

Please briefly describe how you personally develop and encourage problem solving and critical thinking skills in your classroom.

Any further comments you have would be appreciated.

Thank you!

Angie, Debbie & Barb

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Appendix C
Parent Survey

Parent Survey

Dear Parent(s)/Guardian(s),

As part of my data gathering for math class, please complete the following survey by placing an "X" on the line nearest the response of your choice.

Does your child appear to have an interest in mathematics?

Not at all	Seldom	Some of the time	Often

My child enjoys figuring out puzzles, brain teasers, word problems or similar activities.

Not at all	Seldom	Some of the time	Often

Do you share your methods of solving problems with your child?

Not at all	Seldom	Some of the time	Often

When confronted with a problem, does your child ask for help?

Not at all	Seldom	Some of the time	Often

Do you discuss with your child the ways <u>you</u> use mathematics every day?

Not at all	Seldom	Some of the time	Often

Thank You!

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Appendix D
Portfolio Tags

My Best Work!
Wow... too cool?
Want my parent to see!
Something I worked hard on!
Something I still don't understand!
I liked doing this!

Appendix E
Annotated Bibliography

Arnold,Tedd(1995).5 ugly monsters.New York:Scholastic
Not Recommended - Did not clearly illustrate the concept of addition and subtraction.

Carle,Eric(19).Rooster's off to see the world.Saxonville, M.D.:Picture Book Studio.
Recommended - Detailed illustrations were useful in depicting the concepts of adding and taking away.

dePaola,Tomie(1988).The legend of the Indian paintbrush.New York:Scholastic.
Recommended - Colorful illustrations helped students visualize the spectrum of colors.

Ernst, Lisa Campell(1983).Sam Johnson and the blue ribbon quilt.New York:Morrow.
Recommended - Excellent story and connected well to the concept of patterns. Children were inspired to create original designs.

Giganti,Paul Jr.(1988).How many snails? New York:William Morrow.
Recommended - Illustrations were useful in depicting the concepts of adding and taking away.

Appendix E
Annotated Bibliography

Hutchins, Pat (1971). Changes, changes. New York: Simon & Schuster.
Recommended - Creative picture book motivated students to design their own shape pictures and recognition of geometrical figures.

Hutchins, Pat (1982). 1 hunter. New York: William Morrow.
Recommended - Illustrations were useful in depicting the concepts of adding and taking away.

Johnson, Stephen T. (1995). Alphabet city. New York: Viking.
Recommended - Photographs allowed children to see and make connections to shapes in their surroundings.

Jonas, Ann (1983). Round trip. New York: William Morrows.
Recommended - Thought provoking black and white illustrations spurred discussion and excitement.

Mathews, Louise (1979). Gator pie. Littleton, MA: Sundance.
Recommended - Amusing storyline enforced the concept of fractions.

McGrath, Barbara Barbieri (1994). The M&M's counting book. Wauwatosa, WI: Charlesbridge.
Recommended - Only to tie in the related activity on probability.

Appendix E
Annotated Bibliography

McMillan,Bruce(1991).Eating fractions.New York:Scholastic.
Recommended - Good introduction to the concept of fractions. Students related well to the children and activities photographed.

Sharmat,Mitchell(1980).Gregory, the terrible eater.New York:Scholastic.
Not Recommended - Did not relate well to the concept of probability.

Sitomer,Mindell/Harry(1970).What is Symmetry.New York: Crowell.
Recommended - The initial sixteen pages were helpful in explaining symmetry. The remainder of the book was not age appropriate.

Testa,Fulvio(1987).If You Look Around You.New York:Dial Books Young.
Recommended- Encouraged observations of shapes in their environment and fostered transfer of the recognition of geometric shapes.

Wegman,William(1995).Triangle,Square,Circle.New York:Hyperion Books for Children.
Recommended - Excellent photographs of geometric shapes.

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Appendix F
Agree/Disagree Chart

AGREE/DISAGREE CHART

Directions: Write statements about a topic your students will study. Give to groups of students *before* and *after* the unit.

TOPIC: The probability of objects floating

STATEMENT	BEFORE		AFTER	
	Agree	Disagree	Agree	Disagree
1. can of soup				
2. shoe				
3. sweet potato				
4. newspaper				
5. banana				
6. cereal				
7. cardboard				
8. rubber heel				
9. appie				
10. egg				
11. waxpaper				
12. carrot				

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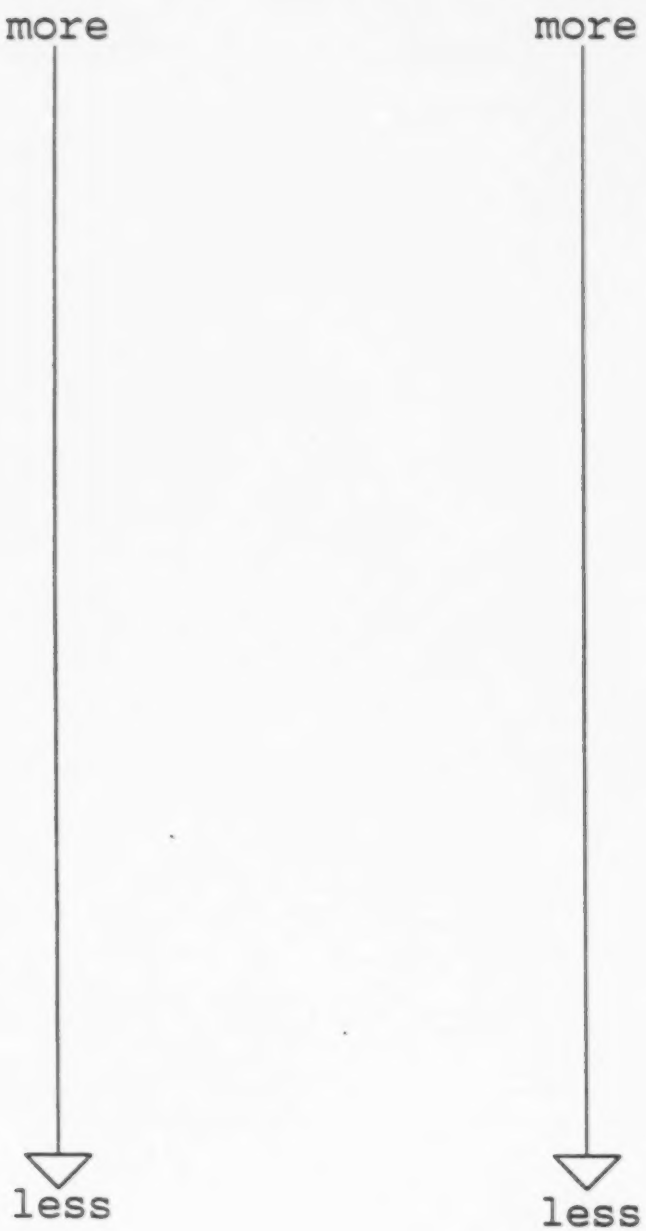
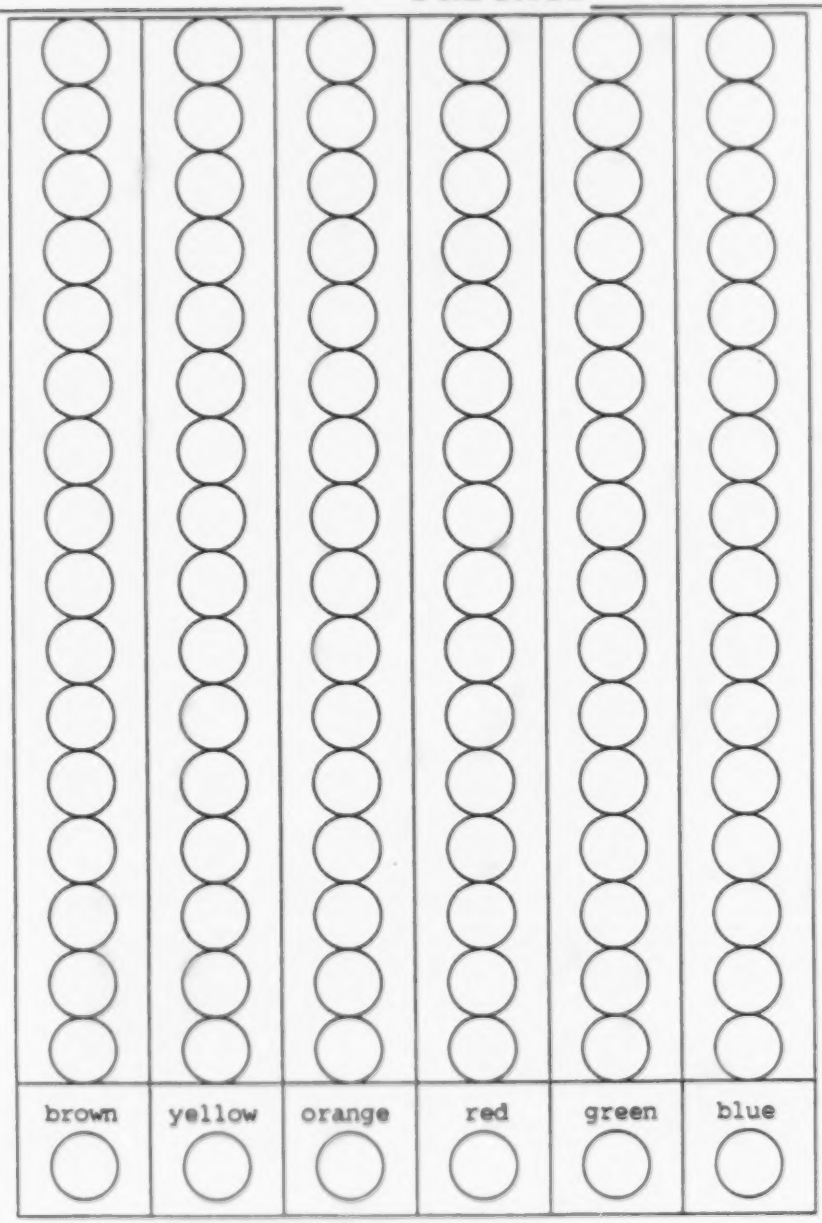
Appendix G
m&m Ranking Sheet



Appendix H
m&m Graph Sheet

m&m activity

Name_____ Partner_____



Appendix I
Probability Performance Assessment

Name_____ Probability Performance Assessment

Which color cube do you think you would pull out most often?

red blue orange

Trials	red	blue	orange
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Teacher Evaluation

no hypothesis no support

hypothesis no support

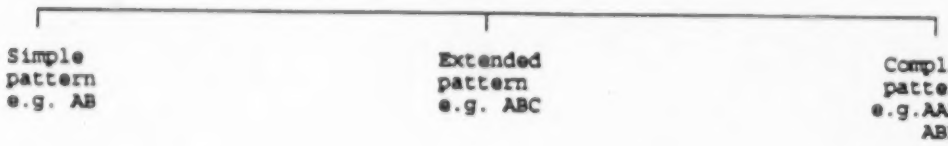
hypothesis invalid but supporting details included

hypothesis valid and accurate supporting details

Appendix J
Pattern Performance Assessment

Name _____ Date _____

Rubric for Pattern Performance Assessment



Appendix K
Geometry Search - Page 1

Name_____ Geometry

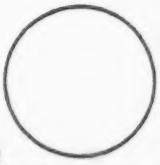
1.

point .

2.

line _____

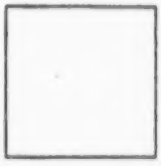
3.

circle 

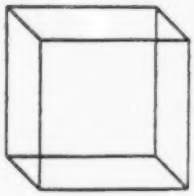
4.

sphere

5.

square 

6.

cube 

Appendix K
Geometry Search - Page 2

7.

triangle

8.

cone

9.

rectangle

10.

rectangular solid

12.

arch

13.

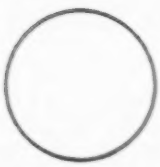
cylinder

Appendix L
Geometry Home Search

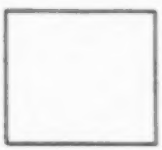
Dear Family,

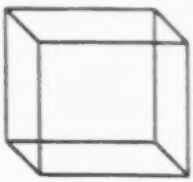
Please help me find 3 to 5 shapes like the ones below to bring in and share with my math class.

Thank you!


circle

sphere


square

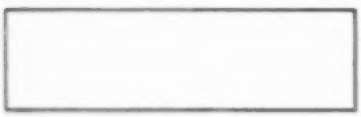

cube

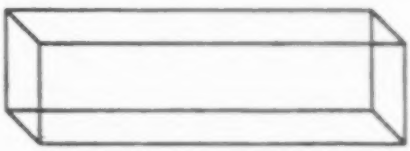
triangle

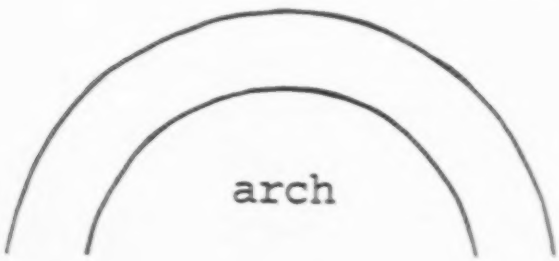
cone

line

cylinder

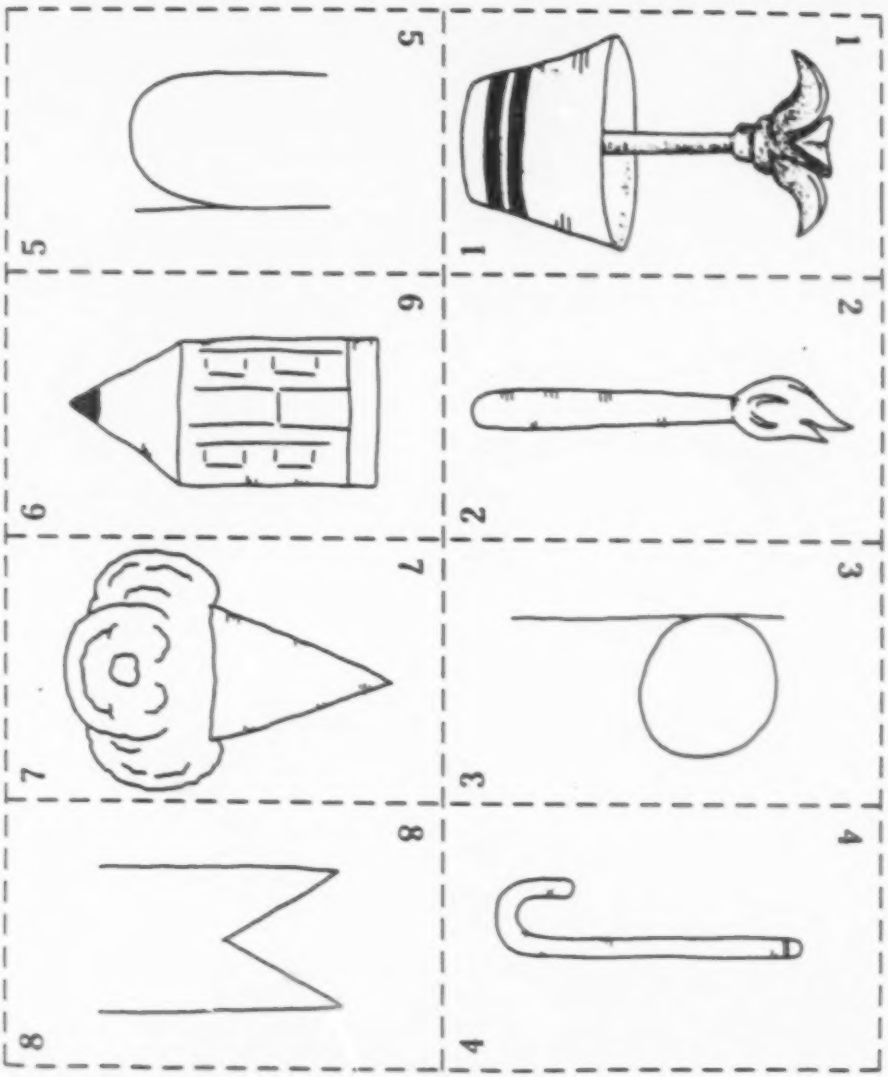

rectangle


rectangular solid


arch

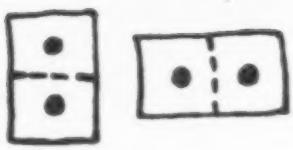
Appendix M
Round Trip Activity Sheet

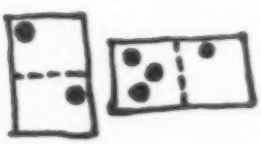
Round Trip



Activity Sheet 23 59

Appendix N
Symmetry - Yes/No Chart

Letters with symmetry... 

Letters without symmetry... 

Appendix O
Geometry Performance Assessment

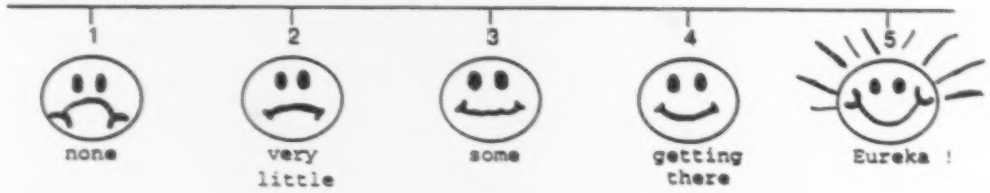
Name _____ Date _____

Rubric for Geometry Performance Assessment

Knowledge of Shapes Displayed

1 2 3 4 5

Creativity and Uniqueness of picture



BEST COPY AVAILABLE

Appendix P
Word Fraction Activity Sheet

Name _____ Partner _____

$\frac{1}{3}$ cut + half $\frac{3}{4}$ = _ _ _ _

$\frac{1}{3}$ pie + four $\frac{3}{4}$ = _ _ _ _

$\frac{1}{6}$ banana + three $\frac{2}{5}$ = _ _ _

$\frac{3}{5}$ gator + table $\frac{1}{5}$ = _ _ _ _

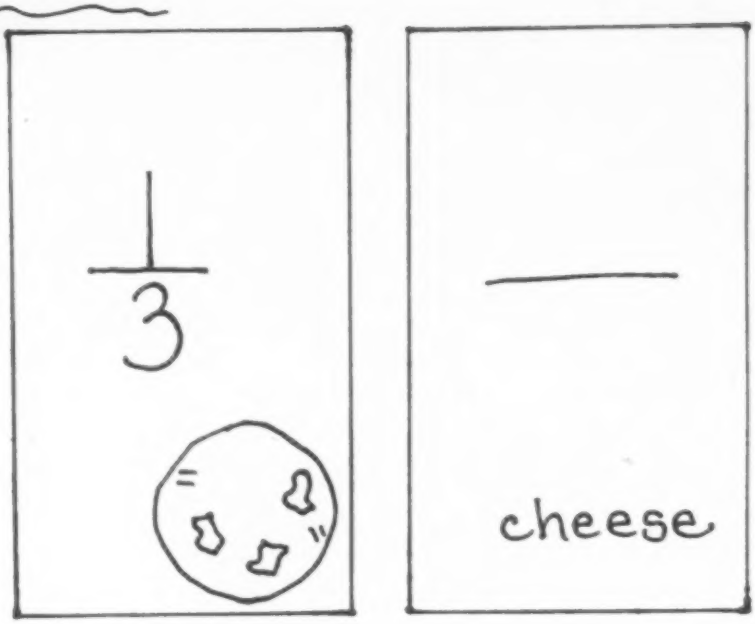
★ $\frac{2}{3}$ pie + marshmallow $\frac{4}{11}$ =

_ _ _ _ _ _

Appendix Q
Fractional Pizza Recipe

Pizza Recipe Cards

(Example)



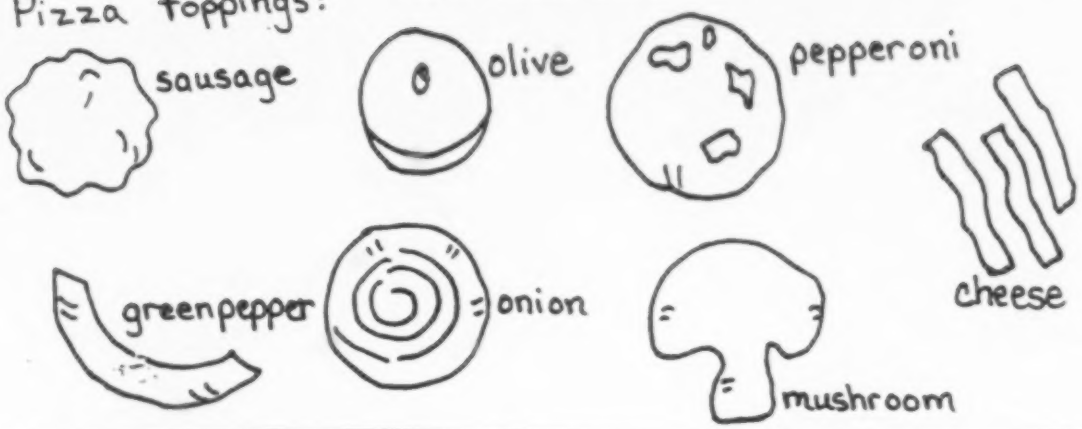
$\frac{1}{3}$ peperoni
$\frac{2}{3}$ mushroom
$\frac{1}{4}$ sausage
$\frac{2}{4}$ green pepper
$\frac{3}{4}$ onion
$\frac{1}{6}$ olives
$\frac{2}{6}$ peppers
$\frac{3}{6}$ mushroom

$\frac{4}{6}$ sausage
$\frac{5}{6}$ green pepper
$\frac{1}{8}$ onion
$\frac{2}{8}$ olives
$\frac{3}{8}$ pepperoni
$\frac{4}{8}$ mushroom
$\frac{5}{8}$ sausage
$\frac{6}{8}$ green pepper
$\frac{7}{8}$ onion

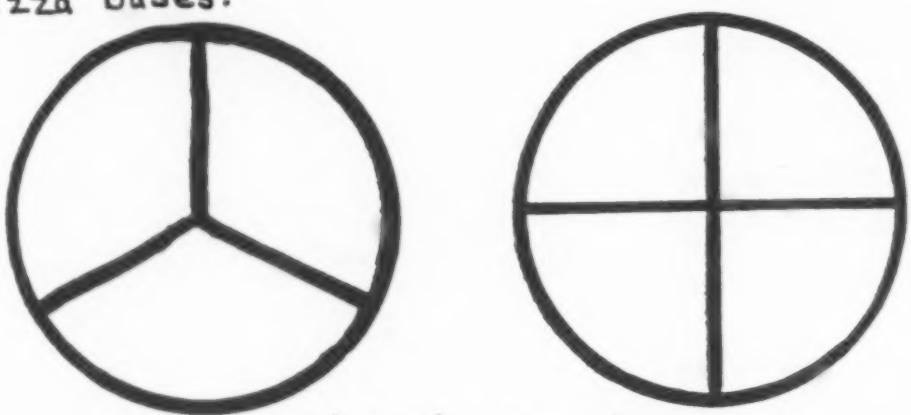
BEST COPY AVAILABLE

Appendix R
Paper Pizza Base

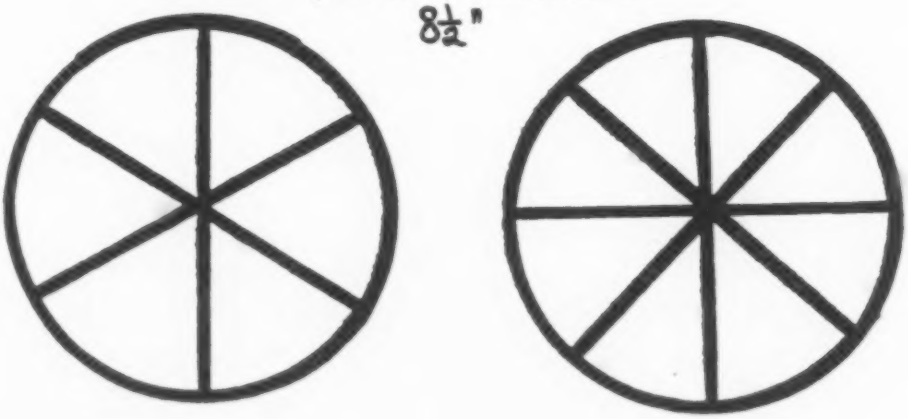
Pizza toppings:



Pizza bases:



Actual diameter
8½"



Appendix S
Fractional Performance Assessment

Fraction Performance Assessment

Correctly chose fractional base (pizza) y/n

Correctly applied topping according to fraction given on instruction card y/n

Correctly identified the fraction of pizza that was cheese only y/n

Date_____